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14. ABSTRACT
This paper describes a method for remotely measuring oscillator frequency using an easily accessible carrier signal. The measurement was based on a system currently used onsite to compare time at the Naval Research Laboratory (NRL) versus USNO via a remotely accessible system. In our case, we are interested in characteristics of the remote system itself. The Washington DC Channel 5 TV station stabilizes the tenth frame of their color sub carrier frequency to a 1PPS signal from USNO with a rubidium oscillator. By performing a high accuracy phase comparison of the 2250 Hz TV5 signal to the 2250 Hz of our local house maser, we can determine the frequency drift of the TV5 rubidium oscillator in real time, to a few parts in 1010 to 1011 . A Windows-compatible computer program was written to facilitate this process. Due to the measured drift, the oscillator will be physically adjusted according to our recommendation during a trip to the TV 5 station this summer.

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REMOTE FREQUENCY MEASUREMENT OF TV 5 RUBIDIUM

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Abstract— **This paper describes a method for remotely measuring oscillator frequency using an easily accessible carrier signal. The measurement was based on a system currently used onsite to compare time at the Naval Research Laboratory (NRL) versus USNO via a remotely accessible system. In our case, we are interested in characteristics of the remote system itself. The Washington DC Channel 5 TV station stabilizes the tenth frame of their color sub carrier frequency to a 1PPS signal from USNO with a rubidium oscillator. By performing a high accuracy phase comparison of the 2250 Hz TV5 signal to the 2250 Hz of our local house maser, we can determine the frequency drift of the TV5 rubidium oscillator in real time, to a few parts in 1010 to 1011 . A Windows-compatible computer program was written to facilitate this process. Due to the measured drift, the oscillator will be physically adjusted according to our recommendation during a trip to the TV 5 station this summer.**

I. INTRODUCTION

At the Naval Research Laboratory (NRL) in Washington DC, a comparison between the local Maser and the US Naval Observatory (USNO) Master Clock is done through a system using the local TV station WTTG (TV 5) and a rubidium clock. A rubidium clock is used to provide a stable reference for the WTTG broadcast transmitter. The incoming signal is mixed with a synthesized reference from the house hydrogen maser. The resulting 2250 Hz is filtered out and compared using a phase comparator. In this experiment, WTTG's rubidium clock frequency was extracted from the signal. The frequency drift was then measured and averaged so the clock can be adjusted at a later date.

II. HISTORY OF TV5

TV 5 originally used a "passive television transmission" to accurately create a "real time synchronization of clocks (Lavenceau, 331)" from various remote locations. The transmission was done using a "portion of a video transmission as a time marker (Lavenceau, 333)", namely line 10. The line 10 was used "by forcing a coincidence between" it and a one pulse per second (1PPS) tick from the local reference clock. The TV frame rate is 33.367 ms, which occurred every 1001 seconds (Lavenceau, 336). Through predetermined Time of Coincidences (TOCs) and a comparison between the house clock's 1PPS and the line 10, a time difference can be calculated and compared between other remote sites. Knowledge of the geographical locations of the sites is needed for the accurate measurement of time delay from the TV 5 site. The clock used at the WTTG station was originally synchronized with a portable cesium clock set to the USNO Master Clock. Line 10 was scrapped by USNO around 1996 when it was no longer needed by the remote sites using it to synchronize their clocks.

III. METHOD OF EXPERIMENTATION

This experiment required the use of the TV 5 observation setup already in use at the Naval Research Lab. The 2250 Hz beat tone from the mixer used in the NRL TV 5 observation setup was sent to the Stanford Time Interval and Frequency Counter SR620. A Windows computer was connected through a GPIB card to the counter took readings at a one second interval. The measurements were then converted into a frequency drift rate by a program called "TV5 Test" written in Visual Basic.

A rubidium clock at the WTTG station provides a stable reference for the 77.240 MHz broadcast signal and is received at both NRL and USNO using TV antennas. At both locations, a 5 MHz sine wave frequency reference signal is synthesized into a 77.242250 MHz signal and mixed with the signal from TV 5. A 2250 Hz beat tone is filtered out from the NRL and USNO received signals, and the USNO beat tone is sent over a dedicated phone line to NRL. NRL's masers are synchronized to USNO's Master Clock by using a phase comparator with the two 2250 Hz beat tones to measure the difference between the two clocks. The rubidium at the WTTG station in Washington DC is not free-run; periodically it must be adjusted by representatives

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from NRL. Measurements for the corrections are taken by the "TV5 Test" program used on the counter.

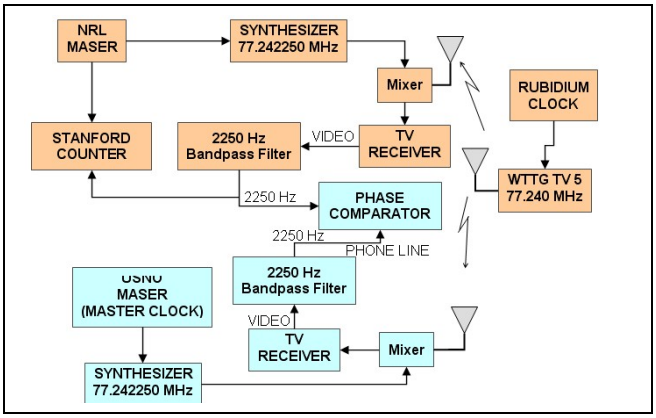

Figure1. Block diagram representation of the current TV 5 system with the TV 5 rubidium frequency drift measurement system added. The parts colored in orange represent the parts used in the measurement of the TV 5 rubidium frequency drift.

The parts that were added to the TV 5 system to perform the frequency drift calculation was a spliced connection from the 2250 Hz beat tone to a Stanford Counter and a Windows computer running the "TV 5 Test" program.

The new Visual Basic program used commands sent through the GPIB card to the Stanford Counter, first checking for the correct counter settings to assure accurate readings. Next the program requested a time difference measurement from the counter, with a 1 second interval between each reading. "TV5 Test" would then calculate the instantaneous frequency drift per measurement interval using a predetermined equation.

$$FREQUENCY\,DRIFT = \frac{(READING - PREVIOUS\,READING)}{1.84} * \frac{2250}{77.24 * 10\text{^}6}$$

The results then were saved in a data file with a timestamp and displayed on a real-time graph (Figure 2).

IV. Results and Conclusion

After collecting 10 days of data and extracting 15.5 hours on 1/13/2005 from 0830 to 2400, the information was stored and analyzed in an Excel spreadsheet. The frequency drift data was then averaged and the standard deviation σ calculated. Measurements that were greater than the average frequency drift plus or minus twice the standard deviation were extracted from the data as outliers. This was repeated two more times to help calculate a better average of the frequency drift of the rubidium clock. The reason the standard deviations needed to be calculated was because crossovers were sometimes very off or were just bad data points and needed to be omitted.

After three outlier extractions the measurements showed a frequency drift averaged at 6.1835x10-10 after 15.5 hours. This will help the NRL representatives going out to the WTTG station tune the rubidium clock. In the future, the program and methods demonstrated will help keep the WTTG rubidium frequency on track through these remote methods.

Acknowledgments

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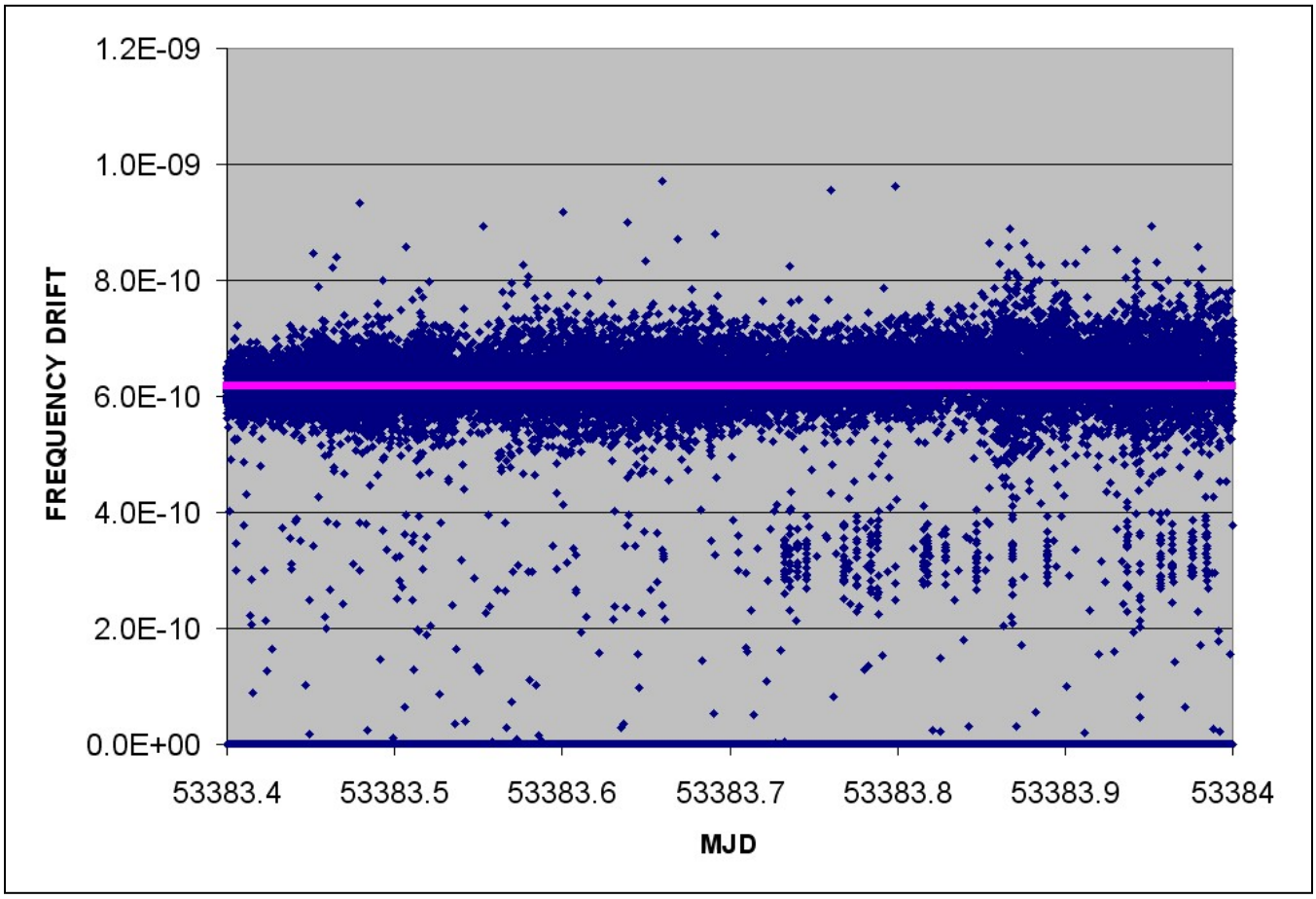

Figure 2. Graph of the frequency drift with 2nd deviation outliers applied. The average displayed as a purple line.